SUTURES AND LIGATURES

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Sterilization. The ideal suture is one absolutely sterile, and which should remain sterile until it is absorbed by the body tissues. It should be strong, flexible and thoroughly absorbable. There is no doubt that catgut can be made sterile, but the question in the minds of the workers with gut is whether it remains sterile until absorbed by the tissues.

Much successful work has been done by surgeons with sterile catgut, but the fact still remains that no matter how clean the operation may be, there is a chance for germs to enter the open wound from the air and to infect the exudate caused by the irritating presence of a foreign body, the catgut. If it were possible to impregnate the gut with an antiseptic which would be non-irritating to the tissues, and which would act during the whole time the catgut were being absorbed, it is probable that germs gaining entrance would be killed, and the danger of suppuration minimized.

The two principal germs against which one must direct his energies in sterilizing the catgut are the *bacillus anthracis*, and the *bacillus tetani*, an infection from either of which means almost certain death. The *bacillus anthracis* may be present in the intestines of a diseased sheep or the gut may be contaminated during the time of removal by contact with some other part of the sheep's body Tetanus is what is known as a soil disease, but the *bacillus tetani* is also found in the contents of the intestines, thus infecting the gut. In addition we have the pus formers, the *staphylococcus pyogenes*, *streptococcus*, etc., and while these may not cause death, they do prevent the normal healing of the wound by first intention.

A great many chemicals, both organic and inorganic, have been introduced as antiseptics for the sterilization of catgut, but have not been universally adopted, most surgeons still adhering to the plain sterile catgut, trusting to their clean technique for success. The iodine catgut has been found to lose its iodine, sometimes within six hours after using, then again it becomes weak owing to the oxidation of the iodine. The organic salts of silver have been used, as have mercuric salts and carbolic acid; none of these seem to meet the requirements as the anti-

septic property is destroyed by the enzymes of the body before the catgut is absorbed.

The many methods which have been put forward from time to time for the sterilization of catgut divide themselves into two main classes, chemical and dry heat. Among those in the chemical class may be mentioned the following solutions: formalin, corrosive sublimate, biniodide of mercury, carbolic acid and pyoktanin.

Formalin solution introduced by Vollmer is a failure, as exposure to the solution long enough for sterilization destroys the tensile strength.

Corrosive sublimate, the method put forward by Bergmann for the sterilization of catgut, will kill germs and spores in a watery solution if it remains long enough and reaches the center of the gut, but as it coagulates the albumen on the surface, it may be doubted whether it would reach spores embedded in the strand. The same can be said of the biniodide of mercury solution.

Carbolic acid has better effect upon resistant spores. Iodine of pyoktanin claudius is probably the best chemical for safe sterilization but the gut becomes weak after a short time. The pyoktanin is a combination solution of tannic acid and iodine, the exact process being a commercial secret.

The efficiency of sterilization by chemicals is rendered doubtful from what is known concerning the action of certain germicides. It is known that carbolic acid and salt of mercury owe their germicidal effect to the fact that they unite with the protoplasm of the bacteria, forming either carbolates or double mercurial salts, and thus rendering them inert, but not insuring their certain death, and in the presence of certain reducing processes, as, for instance, the action of the hemoglobin of the blood, a reduction may take place to such an extent that the germs may again resume their life activities.

Sterilization by heat is effected in different ways by the manufacturers. Boiling in water would be by far the easiest method for sterilizing the gut, but this is impossible because boiling water would change the collagen into gelatine thus destroying the material. To preserve the collagen, the gut must be sterilized in fluid which does not allow these changes. Sterilization in a water-free fluid requires the same degree of heat as is needed for sterilizing with dry heat without a fluid.

By Hofmeister's method the gut is soaked in a solution of formalin, which causes a hardening of the collagen so that it may be boiled for a short time. The sterilization can be only on the surface for if the boiling is continued a sufficient length of time, the water penetrates the interior of the gut and it is destroyed.

Elsberg boils the gut in a concentrated solution of sulphate of ammonia, which prevents the collagen from being converted into gelatine. It is boiled at a temperature of 226° F. This again is only a surface sterilization, for if the water in the solution penetrated the gut it would ruin it. It is only a dry heat sterilization at an inadequate temperature.

Boiling in absolute alcohol is another case of dry sterilization at a low temperature. Hot air (Reverdin) can be used if the gut is absolutely free from water. The gut will stand a temperature of over 165°C. This gives a dry and rough gut which is absolutely sterile.

Of all the methods known to science, the one which theoretically and practically gives a sterile gut is that of Koenig, which is boiling the gut in cumol. Cumol is a coal tar product which boils at a temperature of 168° to 178°C. It has been found that when catgut is placed in this fluid, and the temperature raised over 165°C., it does not lose much of its tensile strength. In this method both the cumol and gut are rendered water free before beginning sterilization. The gut is gauged for size, cut into strands of different lengths, and placed in glass test tubes. These are put into racks, and immersed in the cumol in a cumol sterilizer. In heating the cumol sterilizer, it requires about twelve hours to raise the temperature to the necessary 165°C. When this degree of heat is reached it is kept there for one hour, when it is allowed to cool. This means that the gut is subjected to a heat of about 150°C. for from nine to twelve hours, sufficient in one application to kill the most resistant spores. This sterilization is repeated on the following day, and it is certain that no organism could survive. The cumol not only allows the application of great heat to the gut, but also deprives it of its fats and waxes and destroys the remnants of muscle and membrane which may have escaped the scraping machine. The gut in the tubes is then washed in sterile chloroform, which removes the cumol. The tubes are then half filled with chloroform or absolute alcohol for preservation purposes, and are sealed by the blowpipe. The sealed tubes are again sterilized under eighteen pounds steam pressure on two succeeding days. Samples are tested bacteriologically for sterility, after which they are ready for use.

The cumol method has been thus minutely described because it is believed to be the best way to prepare surgical catgut. It produces an article sterile beyond question, which is sufficiently strong and keeps well.

The Van Horn method of sterilizing the catgut suture is by subjecting it to intense dry heat at a temperature of 250° F. for two hours the first day, 310° to 315° F. for two hours the second day, and 250° F. for two hours the third day; after this the tubes are sealed, and again

subjected to twenty-five pounds pressure of live steam for one hour on the fourth and fifth days. The catgut is preserved in a solution of 99.25 per cent alcohol, and just sufficient chloroform to prevent the gut from absorbing any of the 75 per cent of water.

The process of the manufacture of the chromic catgut is as follows: The gut selected as to gauge is chromicized for a given time in solution containing 6 per cent potassium dichromate and 3 per cent hydrochloric acid. The time of treatment depends upon the desired rate of absorption and varies from one-half to three hours. The gut is then dried in the dark to prevent oxidation. When dry it is thoroughly washed and neutralized, thus getting rid of the water and soluble compounds which would sooner or later ruin the product. The gut is suspended by means of weights and so allowed to dry in a state of tension. When dry the sutures are sorted for the different sizes, placed in open tubes in the cumolizer and subjected to a temperature of 165°C. for one hour on two days. It is then washed free of cumol by means of chloroform; the tubes are half filled with chloroform and absolute alcohol, sealed and again sterilized under eighteen pounds live steam pressure for one hour on two days.

The chromic catgut is prepared to resist absorption in the body tissues for from ten to forty days. This is governed largely according to the length of chromizing process, size of suture, and the kind of body tissues in which the suture is placed. The sizes range from number 00 to number 4.

Non-absorbable ligature and suture materials. Absorbable ligature and suture materials of some variety were first used for the closure of superficial wounds, and continued to be used for that purpose until the iodized catgut was introduced. As previously stated, the non-absorbable ligature, and suture materials are the silk, linen, silkworm gut, etc.

The silk ligature and suture is a product of southern France. There are two varieties of silk ligatures and sutures, the black, which is iron dyed, and the white, the natural color. The threads are either twisted or braided according to the sizes desired. The black, iron-dyed, twisted silk thread is by far the most satisfactory, the color having the advantage of being readily seen, as these sutures are not absorbable. The silk sutures are in most cases sent to the hospital in an unsterile state. The usual method of sterilization is boiling in water just before use. There is a specially prepared silk which is always ready for immediate use; this is preserved in a sealed tube of fluid "Interol" which is sterilized by dry heat.

The linen thread is produced in America and England. It comes in three varieties, black, white and gray. This also comes in an un-

sterile condition to the hospital and is sterilized by means boiling of just before use.

The Pagenstachers linen, or celluloid hemp comes to us from Germany. It was introduced by the German surgeon Pagenstacher as a substitute for silk sutures. The suture is prepared by boiling linen thread in a solution of sodium bicarbonate one per cent and drying, then soaking the dry thread again in liquid celluloid.

The wires, gold, silver and iron, are little used except for the wiring of bones and fractures. The silver wire was used in the early days of gynecology. It was first introduced for this purpose by Dr. Marion Sims, for the closing of vesico-vaginal fistula. The method of sterilization is boiling just before using.

The best horsehair is produced in America, it is gathered expressly for this purpose from healthy live animals. There is no special method of preparation, except that of cleansing with soap and water, then steaming or boiling just before use, or preserving in alcohol or sterile water. Many surgeons prefer horsehair in suturing the face, lips, neck and scalp because of the very delicate scar it leaves. This is due not only to the fineness of the material, but also to the fact that it cannot be tied too tightly, consequently there is no such thing as necrosis from strangulation when it is used. It is also a favorite suture for integumentary sutures by surgeons.

Silkworm gut is a product of France and is obtained from the silkworm just before it is ready to spin. There are two glands or pouches, one on either side of the lower part of the body of the worm, which secrete a liquid silk to be spun into the cocoon by the worm. The worm when ready to spin is dropped into acetic acid, which gelatinizes the liquid silk in the gland and kills the silk worm. The glands are then removed and the mass is pulled out into threads of varying sizes, fine, medium, and heavy. The silkworm gut is sterilized by boiling just before use or it may be preserved in alcohol or chloroform. It is also prepared by manufacturers in sealed tubes ready for immediate use. The silkworm gut is put into the tubes containing a solution of 99 or 75 per cent alcohol, just enough chloroform to prevent absorption of water, sealed and sterilized.

In conclusion, the fact should be noted that the efficiency of modern surgery depends not only upon painstaking care on the part of the producer of these various materials, but also upon the careful handling of them by the surgical nurse before and during assistance to the surgeon. A very slight mistake on her part may undo all the value of the arduous preparation and sterilization.